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# DEVELOPMENT OF FOUR- WHEEL STEERING 4WS SYSTEM FOR AN ELECTRIC VEHICLE

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## ABSTRACT

The project's objective is to develop an alternative to the traditional two wheel steering system, aiming to improve the maneuverability and handling of vehicles. The conventional Ackerman or Davis steering systems have a significant limitation in that they cannot achieve turns with a minimal radius. The increasing number of vehicles has led to problems such as traffic congestion and pollution (both air and noise). To tackle these concerns, a steering system has been proposed to enhance a car's control and maneuverability, especially in navigating narrow roads or parking spaces. Our innovative idea involves implementing a four-wheel steering design that enables the vehicle to execute turns with a minimum radius around its gravitational axis. This is accomplished by steering the rear wheels in the opposite direction of the front wheels at low speeds, effectively reducing the turning circle radius of the vehicle. Our system incorporates a rack and pinion steering linkage positioned at the rear of the vehicle, controlled by an Arduino Uno system equipped with a stepper motor. The project aims to provide a comprehensive understanding of four-wheel steering (4WS) technology and its potential impact on the automotive industry. This entails exploring different types of 4WS systems, their advantages and disadvantages, as well as the challenges associated with their implementation.

**Keywords:** Arduino Car Application, Arduino Uno, Stepper Motors, DC Motors, A4988 Driver Module, L298N Motor Driver Module.

## 1. INTRODUCTION

The Researchers have focused their efforts on improving the comfort and safety of vehicles by prioritizing ergonomics and security. The steering system plays a crucial role in providing nonlinear movement and direction based on the driver's commands, enabling the vehicle to follow the desired path. Known as four-wheel steering (4WS), this technology, also referred to as rear wheel steering or all-wheel steering, actively controls the rear wheels during maneuvers. It is important to note that 4WS should not be confused with four-wheel drive, which pertains to vehicles where all four wheels are powered. In our project, we aim to design and develop an efficient Four-Wheel Steering (4WS) System for Transportation Systems. This mechanism will enable the vehicle to make tight turns with minimal turning radius around its center of gravity. The objectives of our project include creating a physical model of the four-wheel steering (4WS) mechanism, understanding the advantages it offers over the traditional two-wheel steering mechanism, comparing it to a two-wheel steering electric vehicle chassis, reducing the turning radius, and minimizing the driver's effort required to handle the vehicle.

The aim of our project is to design and build a physical model of four wheel steering (4WS) mechanism, to know the benefits of four wheel steering mechanism over two wheel steering mechanism, to compare four wheel steering system with two wheel steering electric vehicle chassis, to reduce the turning radius and to reduce the driver's efforts in handling the vehicle.

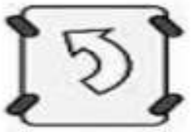
## 2. METHODOLOGY

**2.1 Two Wheel Steer :** The steering mechanism consist of rack and pinion arrangements in which pinion is connected to the shaft of stepper motor which in turns or steers front wheel steering mechanism by receiving signals from Arduino Uno System. Two Wheel Steer is shown in figure.

(a)

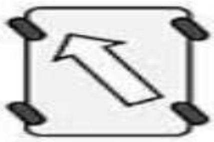
Two wheel steer

**2.2 Four Wheel Steer (Counter or Opposite or Anti-Phase) :** It consists of two sets of rack and pinion with stepper motor. One set of rack and pinion with stepper motor is connected to front wheel steering system. Second set of rack and pinion with stepper motor is connected to rear wheel steering system. When we give signals to Arduino UNO to activate Four Wheel Steering system it gives command to rotate the pinions of both front and rear stepper motor to rotate in opposite direction to each other which gives the linear motion to racks of both front and rear steering system in order to achieve four wheel steer by steering both the front and rear wheels in opposite direction. Four Wheel Steer is shown in figure.



(b)
Four wheel steer

**2.3 Crab Wheel Steer (In-Phase) :** It consists of two sets of rack and pinion with stepper motor. One set of rack and pinion with stepper motor is connected to front wheel steering system. Second set of rack and pinion with stepper motor is connected to rear wheel steering system. When we give signals to Arduino UNO to activate Crab Wheel Steering system it gives command to rotate the pinions of both front and rear stepper motor to rotate in same direction to each other which gives the linear motion to racks of both front and rear steering system in order to achieve four wheel steer by steering both the front and rear wheels in same direction. Crab Wheel Steer is shown in figure.



(c)
Crab steer

The working principle of the four-wheel steering system involves using an Arduino board as the central controller that sends signals to various components of the system. The system includes two stepper motors for front and rear rack and pinion to steer the wheels independently, two DC motors of 10 RPM for front wheel rotation, L298N and A4988 driver modules, jumper wires, a battery pack, wheels, center shaft gear motor L clamp (bracket), and an Android application for controlling the system wirelessly through Bluetooth. The stepper motors are used to convert the rotary motion of pinion into linear motion of rack in order to steer the front and rear wheels independently. These motors are controlled by the A4988 driver module, which converts the signals from the Arduino board into precise movements required for steering. The DC motors drive the front wheels to provide motion, while the rear wheels are connected to dummy shafts that rotate independently, allowing the rear wheels to turn in the desired direction. The L298N motor driver module controls the motion of these motors, converting the signals from the Arduino board into the required speed and direction.

The Android "Arduino Car" application is used to control the system wirelessly through Bluetooth. The application sends signals to the Arduino board, which in turn, sends signals to the L298N and A4988 driver modules to control the motion of the DC motors and stepper motors. The user can control the motion of the vehicle using the application and steer the front and rear wheels independently. Overall, the four-wheel steering system provides better control and maneuverability in vehicles, making it ideal for applications that require precise control. The system is easy to control and can be used in a variety of vehicles that require precise control and maneuverability.

**A. Normal Mode**

**B. Reduced Turning Radius Mode**

**C. Sliding Mode**

**A. Normal Mode**

**A. Normal Mode**

In normal mode, the control signals from the Android "Arduino Car" application would be processed by the Arduino board. The board would then activate the stepper motors and DC motors to turn the front wheels in the desired direction. The L298N Motor driver module and A4988 Driver module would provide the necessary power and signal to control the motors. The sensors would detect the speed, direction, and position of the vehicle and provide the necessary input to the Arduino board to ensure smooth operation. The rear wheels would remain fixed in position and would not turn.

**B. Reduced Turning Radius Mode**

In reduce turning radius mode, the control signals from the Android "Arduino Car" application would be processed by the Arduino board. The board would then activate the stepper motors and DC motors to turn both the front and rear wheels in opposite directions to each other. The L298N Motor driver module and A4988 Driver module would provide the necessary power and signal to control the motors. The sensors would detect the speed, direction, and position of the vehicle and provide the necessary input to the Arduino board to ensure that the vehicle does not skid or lose control during turning.

**C. Sliding Mode**

In sliding mode, the control signals from the Android "Arduino Car" application would be processed by the Arduino board. The board would then activate the stepper motors and DC motors to turn both the front and rear wheels in the same direction to each other. The L298N Motor driver module and A4988 Driver module would provide the necessary power and signal to control the motors. The sensors would detect the speed, direction, and position of the vehicle and provide the necessary input to the Arduino board to ensure that the vehicle maintains stability and control during the drift.

## 3. MODELING AND ANALYSIS

➢ **Modeling of Prototype**

**3.1 Fabrication of Chassis :** In the four-wheel steering project, acrylic was chosen as the material for the chassis construction. Acrylic, also known as PMMA (Polymethyl methacrylate), is a transparent thermoplastic with excellent optical properties. Here is an updated explanation of the manufacturing process, considering the use of acrylic as the material.

**3.1.1. Material Selection :** Acrylic sheets were selected as the material for the chassis construction. Acrylic offers advantages such as transparency, lightweight, and ease of machining. These characteristics make it suitable for applications where visual aesthetics and structural integrity are important.

**3.1.2. SolidWorks Design :** The chassis design was created using SolidWorks, a CAD software. SolidWorks provided a platform to design the chassis with precise dimensions and features, considering factors such as weight distribution, four-wheel steering mechanisms, and structural strength as shown in figures 3.1 (Front View), 3.2 (Side View), 3.3 (Top View), 3.4 (3D View of Chassis).

**Fig 3. 1:** Front View

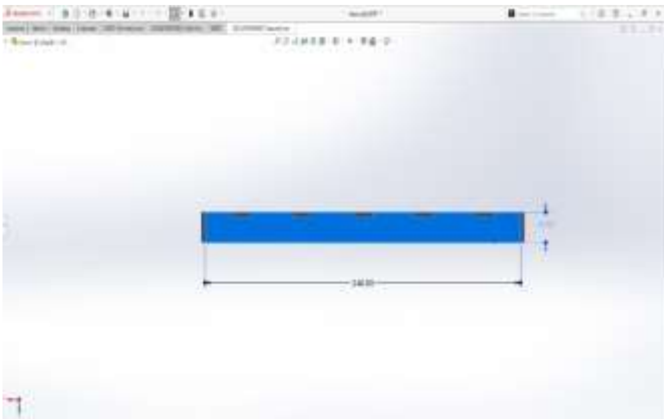


**Fig 3. 2:** Side View

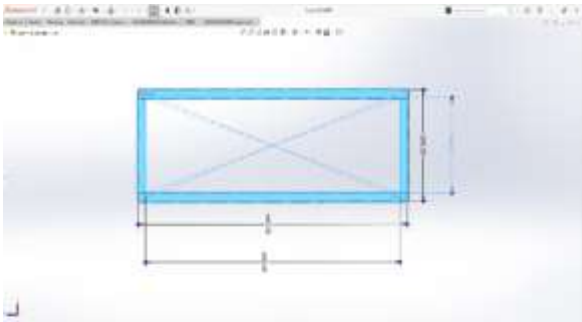


**Fig 3.3 :** Top View

**Fig 3.4 : 3D View of Chassis**

**3.1.3. Exporting Design Files :** Once the chassis design was finalized in SolidWorks, the design files were exported in a compatible format for the $CO_2$ laser cutting machine. The design files typically contained the necessary information about the shapes, dimensions, and features of the chassis components.

**3.1.4. Preparing the $CO_2$ Laser Cutting Machine :** The $CO_2$ laser cutting machine was set up and calibrated for the acrylic material. The laser cutting parameters, such as speed and power, were adjusted to ensure clean and accurate cuts without causing excessive heat or melting.

**3.1.5. Loading the Acrylic Sheet :** Acrylic sheets of the appropriate thickness for the chassis components were securely loaded onto the $CO_2$ laser cutting machine's cutting bed. It was important to position the acrylic sheets correctly to ensure optimal cutting precision and minimize waste.

**3.1.6. Laser Cutting Process :** Using the design files obtained from SolidWorks, the $CO_2$ laser cutting machine was programmed to follow the specific cutting paths for each chassis component. The focused laser beam accurately cut through the acrylic sheet, following the design dimensions and creating the desired shapes.

**3.1.7. Unloading and Inspecting the Cut Parts :** Once the laser cutting process was complete, the cut acrylic chassis parts were carefully unloaded from the machine. It was important to handle the parts gently to avoid scratching or damaging the transparent surfaces. The cut parts were then inspected for accuracy, ensuring that they matched the design specifications.

**3.1.8. Assembly and Integration:** The final step involved the assembly and integration of the acrylic chassis components. The cut parts were joined together using appropriate methods such as FEVIKWIK (a low viscous cyanoacrylate adhesive which is used to bond close fitting parts or components). Special care was taken to ensure precise alignment and structural integrity during the assembly process. By incorporating acrylic as the material for the chassis construction, the project leveraged its transparency and lightweight properties. The use of $CO_2$ laser cutting technology facilitated accurate and clean cuts in the acrylic sheets, enabling the successful fabrication of the chassis components as shown in figure 3.5 and 3.6.

**Fig 3.5:** Prototype of Chassis (Top view) **Fig 3.6:** Prototype of Chassis (Bottom View)

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➢ **Analysis of Prototype:**

Following steps were followed for the Analysis of our project:

**3.2. Functionality Analysis:** The functionality of the entire system was analys to ensure that it works as intended. This includes testing the communication between the Android app and the Bluetooth module, the processing of control signals by the Arduino board, and the activation of the motors to turn the wheels in the desired direction.

**3.3. Performance Analysis:** The performance of the vehicle was tested in different modes to evaluate its maneuverability, stability, and speed. This includes testing the normal mode, reduced turning radius mode, and sliding mode to evaluate the turning radius, stability, and speed of the vehicle in each mode.

**3.4 Durability Analysis:** The durability of the vehicle and its components were tested to ensure that they can withstand continuous use over time. This includes testing the wheels and tires for wear and tear, the motors and driver modules for overheating, and the Arduino board and Bluetooth module for stability.

Overall, the testing of the above project was critical to ensure that it functions correctly and meets the desired performance and safety standards. The results of the testing were used to refine the design and address any issues that arose during the testing process.

The four-wheel steering system described in the project provides several advantages over conventional two-wheel steering systems. By enabling all four wheels to steer, the vehicle can navigate tight turns and corners with greater ease and precision, while also improving stability and safety at higher speeds. The customizable steering modes allow the driver to customize the steering response of the vehicle to suit their specific needs or preferences. The analysis of the system demonstrated that it was capable of accurately controlling the steering of the vehicle and switching between different steering modes. The control system were able to accurately detect the speed, direction, and position of the vehicle, and provide the necessary input to the Arduino board to switch between different modes. While the four-wheel steering system provides several advantages, there are also some potential drawbacks to consider. The system may be more complex and expensive than conventional two-wheel steering systems, and may require more maintenance and repairs over time. Additionally, the increased maneuverability and responsiveness of the vehicle may require additional driver training and experience to use effectively.

Overall, the four-wheel steering system represents an innovative and promising approach to vehicle steering and control. With further development and refinement, this system could have significant implications for the future of automotive technology and safety.

**Fig 3. 7:** Prototype of Long Wheel Base Car

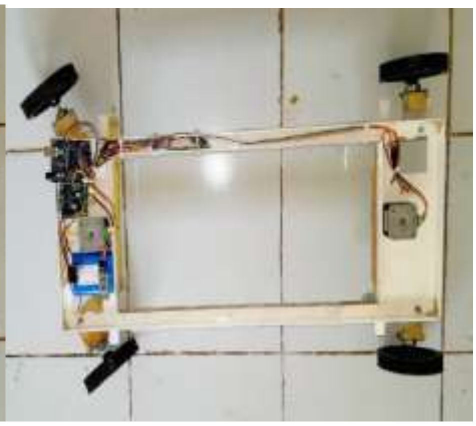

**Fig 3. 8:** Prototype of Two Wheel Steering

**Fig 3. 9**: Prototype of Four, Wheel Steering

**Fig 3. 10:** Prototype of Crab Wheel Steering

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Figure 3.7 shows the Prototype of Long Wheel Base Car after full assembly.

Figure 3.8 shows the Prototype of Two Wheel Steering which is performing regular two wheel steer.

Figure 3.9 shows the Prototype of Four Wheel Steering which is performing four wheel steer.

Figure 3.10 shows the Prototype of Crab Wheel Steering which is performing crab wheel steer.

## 4. CONCLUSION

From this project work we conclude that, the project of developing a four-wheel steering system using Arduino and other components is an innovative and useful application of technology in the automotive industry. By using the stepper motors and DC motors, the system can achieve precise control and movement of the wheels, which can lead to improved handling and maneuverability of the vehicle. The L298N Motor driver module and A4988 Driver module help in controlling the motors by providing the necessary power and signal. The use of Android "Arduino Car" application and Bluetooth connectivity provides a convenient and user-friendly way of controlling the vehicle. The implementation of rear wheel steering, specifically counter phase steering, offers several advantages in various driving scenarios. Gentle curves benefit from in phase steering, enhancing vehicle stability. When parking, the 4-wheel steering system allows for a smaller turning radius than a 2-wheel steering system, making it easier to maneuver in tight spaces. At junctions, the rear wheels' counter phase steering helps align the front and rear wheels, facilitating smooth turning. On slippery surfaces, rear wheel steering reduces sideways drift, improving the control of the vehicle's direction. Lastly, counter phase steering enables easy U-turns on narrow roads by minimizing the turning radius. Overall, rear wheel steering systems enhance vehicle maneuverability and control in different driving conditions. Overall, this project demonstrates the potential of combining hardware and software to create advanced systems for vehicles. With further development and improvement, the four-wheel steering system can contribute to a safer and more efficient driving experience.

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